Radiological Operations on the Modern Battlefield

By Major Kevin Hart

Chemical Soldiers must deal with chemical, biological, radiological, and nuclear (CBRN) threats on the battlefield, regardless of their level of training and experience with these hazards. Radiation sources have been encountered during every major operation since Operation Joint Endeavor in Bosnia; however, until recently, only a small contingent of Dragon Soldiers was trained in radiation safety and had the skill set necessary to safely handle the "R" in CBRN.

Radiological sources range from common radioactive materials found in military units, such as tritium in fire control devices and nickel-63 in chemical detection equipment, to high-activity sources found in industry or contained in a terrorist's "dirty bomb." The old nuclear, biological, and chemical (NBC) paradigm only addressed nuclear hazards that affected the current operation. However, the shift in concern regarding the effects of full-spectrum CBRN threats has made it imperative that Dragon Soldiers be savvy in the art and science of identifying and mitigating hazards which may pose short- and long-term health risks to Soldiers.

Limited training is only one of the problems faced by Dragon Soldiers who handle radioactive materials. Doctrine for nuclear contamination avoidance (Field Manual [FM] 3-3-1, *Nuclear Contamination Avoidance*) only addresses radiological sources in a single-page chapter (Chapter 8).[1] However FM 3-11.4, *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection*, includes an appendix dedicated to full-spectrum radiological protection. Simple guidelines can help chemical staffs and units develop a plan to identify hazards, assess threat, and protect Soldiers from unnecessary exposure.

Training

Of all possible CBRN threats, radiological threats are the easiest to assess and manage, given current instrumentation. The difficulty is overcoming a natural fear of radiation and dealing with unfamiliar radiation measurement units. Some people are under the impression that thousands were killed from radiation released in events such as those that occurred at Three Mile Island (TMI) and Chernobyl. In reality, nobody died as a result of the accident at TMI, and 31 responders died as a result of the accident at Chernobyl.

If properly used, radiation detection instrumentation provides a real-time indication of whether an area is safe or not and, if it is, how long Soldiers can safely stay. None of the chemical-biological (CB) detection systems can provide this type of information so quickly and accurately. The key to success in responding to radiological threats is to have a good understanding of the capabilities and limitations of radiac equipment and know how to use data obtained with the equipment. Historically, detectors were rarely taken to the field for training. Now, however, new commercial trainers, which make use of global positioning systems, allow for more flexibility in training. The trainers may be configured to replicate situations like a radiological source in a shipping container or an area contaminated by a dirty bomb. Hands-on exercises are now a key component of radiological training.

An understanding of radiation measurement units is another key component to the successful management of radiological operations. The amount of exposure, the dose, and the dose equivalent are used to indicate how much damage may occur to an individual exposed to radiation. Problems arise when radiation measurement units must be converted, as many of the units are in simultaneous common use, depending on which radiation detection instrument is used. The ability to understand, convert, and compare values is enhanced when these units are properly aligned with respect to one another, as follows:

$$1\,roentgen\,(R) = 1\,rad = 1\,rem = 1\,cGy = 1\,cSv$$

Where—

R = *measurement of the electrical charge in the air resulting from X-ray or gamma radiation.*

rad = *the standard unit of absorbed dose or the energy deposited per gram of tissue mass.*

rem = *the dose equivalent of the radiation where the quality factor for X-rays and gamma radiation is 1.*

cGy = *centigray, the International System of Units (SI) unit of absorbed dose.*

cSv = *centisievert, the SI unit of dose equivalent.*

Units of activity are other units that are used. Activity is a measure of how much radioactive material is present. It is measured in disintegrations per second and expressed as curies (Ci) (where 1 curie is equal to 3.7×10^{10} disintegrations per second—a great deal of radioactive material) or, using SI units, as bequerels (Bq) (where 1 Bq is equal to one disintegration per second—a small amount of radioactive material). For hazard analysis or risk assessment, the exact quantity of radioactive material present is not as important as the general magnitude. The relative hazard of various generalized quantities of radioactive material, in both standard and SI units, is provided in the table below.

Hazard	Standard Unit*	SI Unit*
High	Curie	Gigabecquerel
Medium	Millicurie	Megabecquerel
Low	Microcurie	Kilobecquerel

*Prefixes have been added to the SI units to make them approximately equivalent to the corresponding standard units.

One of the most important aspects of protecting Soldiers from radiation exposure is knowing how much radiation is too much. The measured dose rate provides an indication of how long a Soldier can stay in an area without exceeding a preselected dose limit or, in military terms, the operational exposure guidance (OEG). For example, if the selected OEG is 25 cGy and the measured dose rate is 0.1 cGy per hour (cGy/hr), then a Soldier can stay in the area for 250 hours before exceeding the 25 cGy OEG. But, if the dose rate is 100 micrograys per hour (μGy/hr), the Soldier can stay in the area for 2,500 hours before exceeding the 25 cGy OEG. This example shows that the higher the dose rate, the less time there is before the OEG is exceeded. This also means there is less time to complete the mission. Risk-based guidance for low-level radiation encountered during military operations other than war is provided in FM 3-11.4 and the soon-to-be published FM 3-11.3, *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Contamination Avoidance*. Armed with an understanding of the use of radiation detectors and units of measurement for radiation, it is possible to plan and safely execute operations in a radiological environment.

Planning

Likely locations of radiological sources should be identified during the mission analysis phase of an operation, rather than by accidentally encountering them during the operation itself. Radiation sources are used in most industries, including steel milling, aluminum foil manufacturing, petroleum processing, and heavy construction. Such industrial facilities should be priorities for requests for information (RFIs) and initial CBRN reconnaissance. Staff planners need to know whether sources located at these sites pose a radiological hazard. The primary information the staff planner uses to assess the threat from a radiological source is the source activity and the dose rate. Many sources are marked with their activity. Activities in the Ci or gigabecquerel (GBq) ranges are considered high-risk. Additionally, any source that has a dose rate in excess of 1 cGy/hr (equivalent to 1 rad/hr) at 1 meter should also be considered high-risk.

Depending on the enemy or civilian situation, radiological sources may need to be secured in place or moved to a controlled area to mitigate the risk. The staff planner must understand the civilian use of radiological sources before making a recommendation. Clearly, removing a source from a radiation therapy facility could have negative consequences for the local population by eliminating the ability to treat cancer. On the other hand, based on a threat evaluation, the benefit of removal may

Relocation of a radioactive waste drum containing radium in Bosnia

prove to outweigh the possible negative effect on the local population. Both the pros and cons must be considered. The identification and mitigation of high-activity, unsecured, or orphan radiation sources must be the priority.

The utilization of all battlefield operating systems must be considered during the development phase of a course of action. A simple operation to move an industrial radiography device from an unsecured construction site to a secured storage location requires much more than a team with radiac equipment. Security, fire support, transportation, radiological monitoring, decontamination, quick-reaction forces, public affairs, and host nation assets must all be synchronized. Even if the threat force has no prior knowledge of the radiation source being moved, the destruction of the vehicle transporting the source could create a radiological incident. Securing sources on site may also be an acceptable alternative. Placing sources in a pit and sealing them with concrete would certainly keep threat forces from easily accessing radioactive material. Consideration must be given to any status-of-forces agreement or applicable environmental regulations. Again, the proper synchronization of assets, along with host nation notification, is imperative.

Mission Execution

The necessity for a clear understanding of task and purpose cannot be overemphasized. Planners should know what survey teams need to accomplish. The survey teams, in turn, should do only what is specifically tasked or can be reasonably inferred from the stated purpose or intent. This is not the time to satisfy curiosity, as that could put the team at risk. For example, if the assigned task is to determine if radiation is present, the team should leave when radiation is detected in excess of ten times the background level. This is the suggested trigger level in determining whether radiation in excess of normal background is present (FM 3-11.4, Appendix D). If the assigned task is simply to determine the number and locations of sources, the team should do just that and refrain from removing those sources from the site.

There is little difference between conducting a conventional chemical reconnaissance mission and a radiological reconnaissance mission. Rather than using a chemical-agent monitor or M8 detector paper, the radiological reconnaissance team uses a radiac instrument. Additionally, the team leader must determine the applicable OEG, turn-back dose (Dtb), and turn-back dose rate (Rtb) for a radiological reconnaissance mission. The Dtb and the Rtb are risk control measures that the team uses to help stay under the OEG. They indicate the measured total dose or the measured dose rate at which the team should abort the mission. The team members still conduct traditional preventive-maintenance checks and services (PMCS), with an additional PMCS requirement to set total dose and dose rate alarms (corresponding to the Dtb and Rtb) on the radiac instrument. The team leader uses an AN/UDR-13 or AN/VDR-2 radiac set to track the unit radiation exposure status (the composite total dose of the unit) in accordance with FM 3-3-1 or FM 3-11.4. Other dosimeters (such as the DT-236 wristwatch dosimeter) or, if a more accurate dose recording is desired, a thermoluminescent dosimeter (TLD) from the US Army Ionizing Radiation Dosimetry Center at Redstone Arsenal in Huntsville, Alabama, may also be used.

For area reconnaissance, the team conducts the same searches and survey patterns specified in FM 3-11.19, *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical Reconnaissance,*

Preventive-medicine detachment collecting soil samples to test for depleted uranium in Kosovo

and, if required, generates an NBC 4 report (release other than attack). For point reconnaissance of buildings, experience is the best guide. The surveyors move deliberately and systematically through the building and its rooms, using changes in radiac readings to locate radiation sources (similar to the method used to play the "hot-warm-cold" game). Inexperienced surveyors often spend too much time monitoring subtle changes in readings. A better technique is to establish a background level, set a trigger of ten times that level, and ignore any readings below that. The surveyor watches for the dose rate to significantly rise and then fall so that the source may be bracketed. He then marks the location with spray paint or another type of marker. The surveyor should keep in mind that gamma rays can travel through walls, so the marked source might actually be behind the wall. The team leader needs to maintain situational awareness of all survey team members to ensure that the surveyor in the adjacent room isn't spending time bracketing the same location. Because high dose rate sources can mask lower dose rate sources, it may be necessary to remove high dose rate sources from the immediate area so that lower dose rate sources may be located. Care must be taken, however, to ensure that neither the intent nor the parameters of the mission are exceeded. In addition, proper safety measures (described below) must be applied when handling any radiation source. The team leader must document the survey—indicating the locations of sources, measured dose rates and, if directed and the team is capable, the isotopes and activities of the sources.

The possibility of contamination of the area in general should also be considered. To check this possibility, the surface of the area being surveyed should periodically be wiped with a small cloth or other appropriate material. The cloth may then be moved to a background area and monitored for radiation. If the reading exceeds five to ten times the background level, the area may be contaminated and the team may need to be decontaminated. The locations where radiation readings were taken and contamination wipes were collected should be documented for later use.

Abandoned industrial radiation sources in Iraq

Safety

Doctrinally (FM 3-11.4, Appendix D), the Rtb is determined by the equation:

$$Rtb = \frac{2 \times OEG \times speed}{distance}$$

However, this equation is only applicable when crossing large, contaminated areas of nuclear fallout in a vehicle. In most cases, a radiologically contaminated area does not fit this criteria. The purpose of calculating a Dtb and an Rtb is to mitigate the risk of radiation exposure by ensuring that the survey team does not exceed the OEG. Because the Dtb and the Rtb augment one another, they must be used together. For building surveys, the Rtb must be adjusted to allow the survey team the maximum opportunity to complete the mission. For example, if the OEG for a mission is 10 cGy and a survey team enters the target facility with an Rtb set at 10 cGy/hr, as long as that dose rate is not exceeded, the team may stay in the location for at least one hour. However, such a low Rtb could seriously limit the team's ability to conduct its mission. Raising the Rtb to 40 cGy/hr would allow work to continue at higher dose rates and, as long as the Rtb was not exceeded, would still permit the team to remain in the location for at least 15 minutes. The Dtb is doctrinally set at half the OEG, which limits the team; it would make more sense to set it at 80 to 90 percent of the OEG if it is expected to take only a short time to exit the radiation field.

Time, distance, and shielding are still valuable tools used to protect Soldiers from unnecessary radiation exposure.

- Limiting exposure time is a great way to keep doses as low as reasonably achievable (ALARA). But how does one go about limiting exposure time? It is done through planning. Developing, rehearsing, and implementing a plan prevents the team from standing in the radiation field trying to decide what to do next. Tasks must be prioritized so that things which really need to be done (putting out a fire, turning off a valve, or reading the information plaque on a high-activity source) are done first.
- Distance is the best method for reducing a radiation dose. If the mission does not require that a Soldier get near the source, he shouldn't.

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A source should never be handled directly; instead, some type of aid (pole, kitchen tongs, shovel, chain, forklift, front loader) should be used. The inverse square law applies to radiation dose rates. Given a dose rate of 10 cGy/hr at a distance of 1 meter, the dose rate at 2 meters would only be 2.5 cGy/hr. On the other hand, the dose rate at 25 centimeters would be 160 cGy/hr.

- Shielding is sometimes the most difficult method to employ. Placing anything between the surveyor and the source reduces the dose, but the denser the material, the better it works. For example, steel makes a better shield than sand. Adequate shielding will most likely need to be coordinated, and the delivery will need to be synchronized. However, existing items (buildings, vehicles, terrain, wooden pallets) may be used as makeshift shielding. In any case, exposure should not be risked for the purpose of placing a shield.

Conclusion

Train the Corps! The need for chemical Soldiers to conduct radiological operations is not going to go away. If anything, it will become more important. Possessing the skills necessary to identify likely source locations and assess and mitigate the threat will continue to demonstrate that the Chemical Corps is a vital contributor on the modern battlefield. Basic analytical skills, training, and practice will be the keys to success.

Endnote

[1]FM 3-3-1 will be superseded by FM 3-11.3, to be published within six months.

References

FM 3-3-1, *Nuclear Contamination Avoidance*, 9 September 1994.

FM 3-11.4, *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection*, 2 June 2003.

FM 3-11.3, *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Contamination Avoidance*, to be published within six months.

FM 3-11.19, *Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical Reconnaissance*, 30 July 2004.

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